INTERACTIONS BETWEEN SUMMER AND WINTER THERMAL COMFORT, EFFECTS OF CLIMATE CHANGE ON OPTIMAL RENOVATION ACTIONS

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Overview

Energy efficiency building renovation, particularly through thermal insulation, is a key factor in the transformation of the building stock to reduce greenhouse gas emissions and adapt dwellings to future climates. Thermal renovation of buildings is a particularly costly operation that rarely pays off for the person carrying out the work. In France, many renovation projects are financed in part by the state, and this funding involves targeting the most effective works. However, this efficiency is only measured in terms of heating needs, while the critical nature of the inadequacy of housing for future heat increases year on year. Taking account of climate change, its future evolution, and the need to adapt homes will therefore influence the optimum renovations to target as a priority now. Here we show that the displacement of the optimum differs according to the type of building and the intensity of warming, and according to the type of renovation work. This study presents a first way of considering dynamic, energy and economic optimisations, with RC modelling of building typologies. The conclusions are different depending on the type of action carried out: for example, the insulation of opaque walls does have an antagonistic effect on heating and cooling needs (but this is particularly visible in the coldest meteorological years and without night-time natural over-ventilation), but total energy needs are always decreasing. Thus, inter-annual variations in typology and weather play a decisive role in defining the optimum. The results call into question the selection criteria for subsidised renovations, as well as the renovations carried out in practice in France. The question of the interaction between summer and winter comfort has been raised in official reports in France, because adaptation is underdeveloped, and the majority of measures are focused on winter thermal comfort. We could ask the following (deliberately provocative) question: 'Do we need to renovate buildings on a massive scale if the French climate warms up significantly between now and the end of the century? The answer is yes, but not for all buildings or all regions in the same way.

Methods

There are many methods for modelling the energy needs of a residential building. The simplest of these are linear and do not allow modelling at fine time steps, of the order of an hour. This temporal precision is necessary to take into account all the phenomena (directed solar gains, thermal inertia of opaque walls, etc.) that influence energy needs, particularly for cooling. In contrast to linear methods, it is possible to use building energy simulation programmes. The resulting models are costly and not very suitable for modelling a national building stock such as the one presented in this study. In our case, the energy requirements are calculated using a single RC model whose form and parameters vary according to the building typology. Sufficiently detailed phenomena such as facade orientation or ventilation rate can then be incorporated. The geometric and thermal parameters are based on data from building typologies carried out on a European scale. For the calculation of energy needs, two other elements must be added:

- Usage behaviour. The setpoint temperatures are taken from conventional methods used in France, as are the internal heat input profiles.
- Meteorological data. The historical data used as a reference comes from the ERA5 project and the prospective data comes from the Explore2 project, combining global climate models and regional climate models for metropolitan France.

Finally, to recalibrate and update the typologies, as well as to quantify the distribution (in terms of number of dwellings and number of buildings) of each typology across the country, we are using data from the TREMI survey on renovation actions in single-family homes, as well as the database of energy performance certificates, managed by the French Agency for Ecological Transition (ADEME).

Results

As a first step, we identified 6 thermal renovation actions that could potentially show interactions between summer and winter comfort. These included: roof insulation, vertical wall insulation, floor insulation, installation of solar shading above windows, changing the colour of external surfaces, and ventilation efficiency. For renovation measures (in most building types and climatic zones), there is indeed an antagonistic effect on energy requirements: heating requirements decrease, while cooling requirements increase, thus contributing to lowering the expected energy gains.

However, overall energy requirements decrease in all cases, and this increase in cooling requirements is mainly true in the case where night-time over-ventilation is deactivated.

The effects of global warming are tending to lower the optimum thickness (from an economic point of view) of insulation, but other works, which are still not widely available in the packages of subsidised offers, can reduce the cooling needs in dwellings. However, these results are highly dependent on the type of building and the different climatic regions.

Conclusions

In conclusion, we have shown how important it is to take account of the dynamic aspect of global warming when deciding on the energy renovations to be promoted at national level. Limiting ourselves to subsidising measures that are useful today could lead to a costly technological lock-in if these measures prove to be detrimental or sub-optimal by 2050 or 2100.

However, it is important to remember that the energy renovation of a building is complex and unique to each building, requiring the skills of experts to minimise the risk of malfunctions. The use of typologies gives us a useful approximation of the French building stock.

References

Loga, Tobias, Britta Stein, and Nikolaus Diefenbach. 'TABULA Building Typologies in 20 European Countries—Making Energy-Related Features of Residential Building Stocks Comparable'. *Energy and Buildings*, Towards an energy efficient European housing stock: monitoring, mapping and modelling retrofitting processes, 132 (15 November 2016): 4–12. https://doi.org/10.1016/j.enbuild.2016.06.094.

Cour des Comptes. 'L'action publique en faveur de l'adaptation au changement climatique'. Cour des Comptes, 12 March 2024. https://www.ccomptes.fr/sites/default/files/2024-03/20240312-syntheses-RPA-2024.pdf.

Giraudet, Louis-Gaëtan, and Lucas Vivier. 'Analyse Socio-Économique de La Rénovation Énergétique Des Logements'. CAE, June 2024. https://www.cae-eco.fr/staticfiles/pdf/focus-106-modelisation-reno-240619.pdf.

Madsen, H., and J. Holst. 'Estimation of Continuous-Time Models for the Heat Dynamics of a Building'. *Energy and Buildings* 22, no. 1 (1 March 1995): 67–79. https://doi.org/10.1016/0378-7788(94)00904-X.

Rouchier, Simon. 'Solving Inverse Problems in Building Physics: An Overview of Guidelines for a Careful and Optimal Use of Data'. *Energy and Buildings* 166 (1 May 2018): 178–95. https://doi.org/10.1016/j.enbuild.2018.02.009.

Pouget Consultants and ADEME. 'Bâtiments résidentiels. Typologie du parc existant et solutions exemplaires pour la rénovation énergétique en France'. ADEME, 2015. https://episcope.eu/fileadmin/tabula/public/docs/brochure/FR_TABULA_TypologyBrochure_Pouget.pdf.

Merlet, Yannis, Simon Rouchier, Arnaud Jay, Nicolas Cellier, and Monika Woloszyn. 'Integration of Phasing on Multi-Objective Optimization of Building Stock Energy Retrofit'. *Energy and Buildings* 257 (15 February 2022): 111776. https://doi.org/10.1016/j.enbuild.2021.111776.

Pannier, Marie-Lise, Thomas Recht, Maxime Robillart, Patrick Schalbart, Bruno Peuportier, and Laurent Mora. 'Identifying Optimal Renovation Schedules for Building Portfolios: Application in a Social Housing Context under Multi-Year Funding Constraints'. *Energy and Buildings* 250 (1 November 2021): 111290. https://doi.org/10.1016/j.enbuild.2021.111290.